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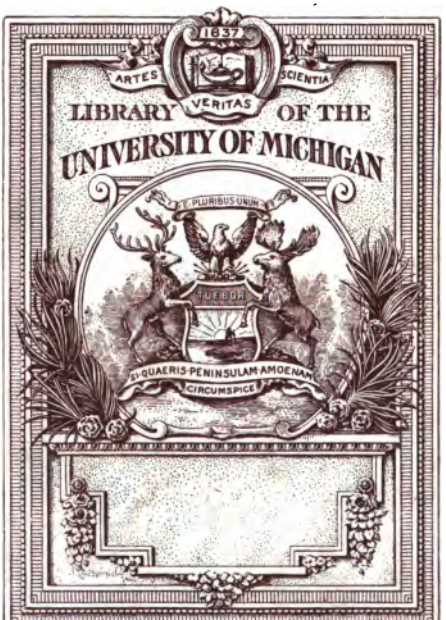
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THE MECHANIC OF THE MOON

DEDICATED TO THE ASTRONOMERS
AND ASTRO-PHYSICISTS

BY

ROBERT SCHINDLER

MEMBER OF THE SOCIETY OF THE FRIENDS OF ASTRONOMY
AND COSMIC PHYSICS

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Robert Schindler

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Author's Preface.

This little work treats on the state, condition, and formation of the surface of the moon, a subject which has been accepted by recent astronomers, but, reasonably, not without a certain amount of distrust. This, for the sake of simplicity, we shall call the "Mechanic of the Moon".

The author has reason to believe that the hypotheses which are expounded in the following pages have been accepted by the majority of modern astronomers and astro-physicists, notwithstanding the seemingly incredible and extraordinary opinions represented.

This work will be distinguished from all preceding treatises on the subject, inasmuch as all matters which are already known to astronomers and astro-physicists, and which may, therefore, be considered as fully or partially exhausted, are omitted, in order that the attention of the reader may not be distracted from the principal point, namely, the Theory of the Mechanic of the Moon.

It will be the author's aim to attract the

attention of the scientists to some other important points, to enable them to find the pathway which leads to an intelligible and acceptable theory as to the Mechanic of the Moon, the private treatment of which is not the object or intention of the author. In the interests of science, therefore, this little work is recommended. On the other hand the author begs leave to place himself at the disposal of any of his kind readers who may desire further elucidation, or enlightenment, and offers them all the assistance and information in his power.

In conclusion he can only hope that this English edition will meet with the same approval and support which has already been accorded to the German and French editions by many notable astronomers and others.

Lucerne, Villa Watt, January, 1906.

Robert Schindler.

Introduction.

The Moon, our faithful companion, is the only object which, in consequence of its relative proximity to our earth, allows, with

the aid of optical expedients, an extended perception of the singular nature of its surface.

The astronomic and graphic arts have splendidly succeeded in making accessible to a larger circle of participants the representations of the surface of the moon, which are incomparable in their magnitude, magnificence, and singularity. Though the moon's surface is well known to many learned men nowadays, and though there is only the question of the priority in discovering insignificancies, we are still in want of a decided statement from some competent authority on one of the known theories as to the origin. The cause of this passiveness on the part of scientists lies especially in the total inadequacy of coincident terrestrial models, and also of a scientifically fixed theory, from which we could deduce the mechanical principle of the beginning of formations on the surface of the moon.

The author is convinced that the investigators of the subject of the moon's construction have had neither the former nor the latter of the above points of support at their disposal, therefore, the solution of this question could not be expected of

them alone; moreover, the hypotheses hitherto made, with their contradictions, were not at all conducive to the search for new theories.

Now one must earnestly ask if there is not to be found a source from which we could derive an explanation about this mechanic, notwithstanding the failure and points of agreement in the massive of nature. The following chapters will answer this question.

I. Origin of the Lunar Surface Elevations.

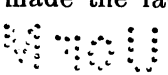
The honoured reader doubtless is aware that hitherto neither the professional scientist nor the amateur student has treated this subject of the Mechanic of the Moon entirely apart from other considerations, and if this occurs with the aid of this work, by an amateur, it will be from special causes which have led him to do it.

The author has collected experiences from various points of observation which are scarcely likely to be accessible to every astronomer and astro-physicist. He has

devoted his attention, for many years, to certain phenomena, and has collected data therefrom which are alone able to led to a right understanding of the formation of the surface of the moon. In other words, the progress of the science of astronomy for its own purposes, seems to exclude the possibility of a right definition of the mechanic of the moon.

The author has studied this question for many years. It is not long ago since he made the remark to two noted astronomers that it has not been possible for science to demonstrate to a conviction this moon theory. It may here be remarked that the author has conducted a machinery factory and iron foundry for twenty-seven years, the same work being now conducted by his nephews. It must be justly admitted that already Ebert and the representatives of the old theories of Hooke, R. Falb, Paul Lehmann and others were approaching towards accuracy. Had those scientists had the experience of many old iron founders, the treatment of this subject would not now be necessary on the part of an amateur. This does not mean, that the inquiring astronomer can simply address himself, without

further consideration, to an iron founder to confirm the opinions which are herein set forth, Nevertheless it is certain that any good iron founder who has had the opportunity of studying this book, would be able to prove the exactnes of what is stated. The iron founder possesses, already in his early practice, the possibility of recognising whether newly founded iron will give a good and perfect, or a defective casting, though the iron be still covered in the mould. This knowledge, obtained by constant experience, can be ascertained by the degree of tranquillity or of agitation in the expulsion of the gases during the process of casting In this manner we shall commence to understand the importance of these phenomena, when we state the fundamental sentence: "All the elevations on the moon have been produced by the gaseous and molten expulsions in a period limited only by the cooling process". This dogma gives the key to this whole moon theory, as in all the movements and dislocations of the material this molten state is always assumed. With regard to the material, as well as the imaginative, processes in the moon, many very clever men have made the fault of seizing upon models from



the earth's mass. This prejudice has led, for example, to the opinion that there exists on the moon air, water, and scoriæ, or muddy scum and rubble, snow and ice, while the contrary theory that none of these elements exist would appear to be the more accurate. On the other hand, that winged word "crater" has led to the fatal consequence, that the character of the volcanic mountains was regarded as the mechanical principle of the lunar formations, and this has induced many investigators to have recourse to hypotheses, which can be easily disproved by all who are familiar with the conduct of molten masses. Klein writes in his "Manual of Astronomy" for the year 1901 as follows:—

"W. Pickering thinks that on account of his observations of the moon made at Arequipa the "mares" are not to be considered as the beds of former seas on the moon, but they had, in his opinion, never presented any other aspect than they do at the present time".

Also he does not find it probable that the moon had ever, like the earth, sustained animal or vegetable life; its surface had

been since the remotest period to all intents a dry and unfertile desert.

In another passage of the same publication he says: "Pickering has looked in vain for evidences of former seas in the mares; indications of these proved, under higher optical power, to be more likely the effects of heat and the molten flood".

The first two of these sentences point to the remotest antiquity of origin, while the last two sentences refer to the heat and flow of molten material. These judgments as to period and properties of matter by Pickering have, in the opinion of the author, been the best which have ever been formed and asserted as to the genesis of the moon's surface, for they suppose the only acceptable mechanical principle of that formation, that is, the liquid state in a period which is only limited by the cooling process.

It may be asked, if there are great difficulties to explain the matter in this manner to those who have never had the opportunity of observing the conduct of gaseous molten masses, so that they may be convinced of the accuracy of processes which are to be dealt with?

The author thinks that, among the scientists for whom this little book is intended, all those who are not under the prejudice of any false hypothesis, will, after profound study, accept with satisfaction, the author's explanations as they can be rightly understood, without special professional knowledge.

II. The Mass of the Moon.

It has not to be ascertained that we all agree in the persuasion that the moon was a glowing molten body before it became a solid mass. We may also accept that those conditions of fusion had existed during the early stages or processes in the formation of our world, but at a much later period. The material of the moon and that of the earth cannot have differed much from each other in those periods of transformation.

Notwithstanding all these conclusions, and even of the analogies between the moon and the earth, the condensation of the crust of the moon and that of the earth subsequent to the first formation of stone had quite a different course, so that the moon, though

much older than the earth, has, in comparison with the latter, quite an embryonic character.

The probable cause of the moon not having passed our granite epoch, lies near at hand, as the moon, presupposing analogy of the material, had eighty times less total heat, while the surface of cooling was only about fourteen times smaller than that of the earth. In this dissimilitude lay the cause of a long series of differences between the two spheres — the moon and the earth — as regards their present state.

In the first instance, every investigator of the moon must consent that there is nothing at all that could be compared, free from objection, with anything on the earth. Farther, the furrows, or rather rents, show, quite clearly, that the extreme outer crust of the moon is composed of brittle or friable quartz, or of glass-like mineral, which must have been rent through and through by the violence of the earliest cooling processes a point to which we shall again refer in the following chapters.

The toughness or tenacity of the mass of the moon in its refractory state of fusion,

which properly belongs to quartz or glass in a molten state, has been rightly perceived, and commented on by Hooke Dane, R. Falb, Schmick, Lehmann and others.

For these kinds of smelt-streams (streams of molten matter) are also speaking the different glowing craters, as well as the crusts of lava or slag which are thrown together over the plains of "mare," to be recognised by the unaided eye as dark plains, but which never attain great height. Here it may be remarked that it must be understood by the word "magma" the mass of the fluid matter and lava or slag, a darker floating crust, which has been exuded by the purifying or refining process, also the jets as well, as the whole dynamics of the moon presupposes, as we shall see later on, the tenacity of the glowing molten substances and the friability or brittleness of the cooling masses, as there always have been savants who have rightly judged the one or the other of these extremes.

The aspect of the surface of the earth at the period of the first cooling, or the granite epoch, might probably have had some resemblance to the aspect of the moon's surface to-day. At a depth of some 35,000 meters

we might perhaps arrive at the crests of craters and ring-mountains, which are still preserved in their original form and have kept the homogeneous character of glass-like fragments which, although forming part of the great upheaval, or catastrophe, have remained intact, inasmuch as the later coagulated deposits have not destroyed these formations.

Such *glassy* formation with its high mountains and almost without scoria in its valleys and profundities forms the bed of the Atlantic Ocean between Greenland and the Azores, about which Termier, of the Academy of Sciences, in Paris, has reported in the year 1899. The question would legitimately arise whether it would not be in the interests of science to ascertain as far as possible the formation of this vast extent of glass-like mountains and valleys.

III. The Explosions.

In beginning this subject it may be remarked that for all the following explanations which have reference to certain objects, the "Parisian Atlas of the Moon" by

Messrs. Lœwy and Puiseux, has been used as the source of information.

Under the title of "Explosions" are understood those functions which have caused the peculiar and typical eminences on the moon. These explosions, or expulsions, have been partly of a gaseous, and partly of a fluid nature, where the gases and vapours produced by the heat and the contraction resulting from the cooling and solidifying (or condensing) operation, were the moving cause.

When the surface of the moon was still in a fluid state, the gases and vapours produced in the interior made their escape through the surface in a similar way, as can be every day seen in the common cooking or melting pot. When the mass begins to thicken this process of evaporation undergoes a change, so that the discharged gases force up the masses from below and deposit these masses on the edge of the aperture thus caused.

In fig. 1 the reader will find an enlarged illustration of the crust of a loaf of bread on which these openings, or exhausted steam holes, caused by the escape of vapour during the process of baking are distinctly

shown. Every student of the moon will admit that there is also on the surface of

Fig. 1.

that sphere something in the nature of these depressions or dimples.

Fig. 2 represents a seal, the edge of which has the form of a real crater, caused by the expulsion of the vapour in the heated sealing wax.

Fig. 2.

Here also it must be conceded that on the moon's surface, as represented in the Parisian Atlas, there are a great number of such

craters, which distinguish themselves by their greater depth and brilliancy in the interior, and which the author has designated by the typical expression "bubble-crater".

There does not exist much difference between a "bubble-crater" and a pit, as both of these owe their origin to exactly the same cause, and are distinguished only by their relative depth — the smaller being known as pits and the larger as craters.

A special kind of these two are the "bruises," covered pits and bubbles, which exist in great number on the surface of the moon, and stand out against the surrounding matter, ground down to lenticular elevations.

This phenomenon is strictly self-evident and has already been rightly so recognised by students, for in every bakery, in sealing wax, in cast iron &c., it occurs when the gases or vapours in the heated material cannot explode the crust and consequently form these "bubble-craters" or inflated hollows.

The formations which come next in order are those which have been caused by gaseous expulsions, and the *contemporary* ejection of magma, — the magma crater. These formations, called by the winged word "crater", have given much occupation to many

great thinkers, while it may be said, the whole theory of the structure of the moon is a relatively simple matter as soon as the true point of view has been ascertained. With the escape of the magma from the interior to the surface occurred the development or evolution of gases caused by the contraction of the crust in the cooling process. At great depths no gases whatever existed in consequence of the pressure of the superstrata, but such gases did exist only at a moderate distance below the surface, and were liberated from the glowing molten mass, and this circumstance caused the acceleration of the expulsions.

The grandeur of the varions forces which were in operation during the formation of a crater by the rush of the molten flood surpasses human imagination. The expanding gases would drive along with undulating motion beneath the molten masses which were forced to the surface where the circumference was only limited by the cooler conditions. The driving asunder and flowing back of the uncooled masses, induced for the time the formation of dams. The result of this movement was that the bases of the craters were partially softened and forced upward,

wherefore all the trough-shaped bottoms of the craters are lying at greater depth than the mass surrounding the rampart or dam.

The author cannot forbear to demonstrate this event, which is well known to him, of the formation of these craters and the plains of the dams. In fig. 3, will be seen a simple and rather primitive looking apparatus for the experimental production of melted eruptions. The thousands of millions of times difference in the cubical proportion of these miniature experiments and the reality makes the use of more tenacious, or specifically heavier, material impossible, and for the purposes of these experiments, nothing more convenient can be used than the easily melted common wax.

The apparatus is advantageously placed on a gas-cooking hearth, and by means of a lever and piston which consists of a tube of 1 inch diameter, being closed at the inferior end, the moderately heated, semi-fluid, wax must be raised on the cake of wax which lies on the plate over the cock. In order to prevent the fusion of the cake of wax by the warmth of the apparatus, a piece of pasteboard with an aperture should be put under the cake, which at the beginning

should also have such an opening of the same size as the dam, as the limitation cannot be well demonstrated in consequence of the smallness. The primitive foot, or base of the lever is not flexible at the lower end,

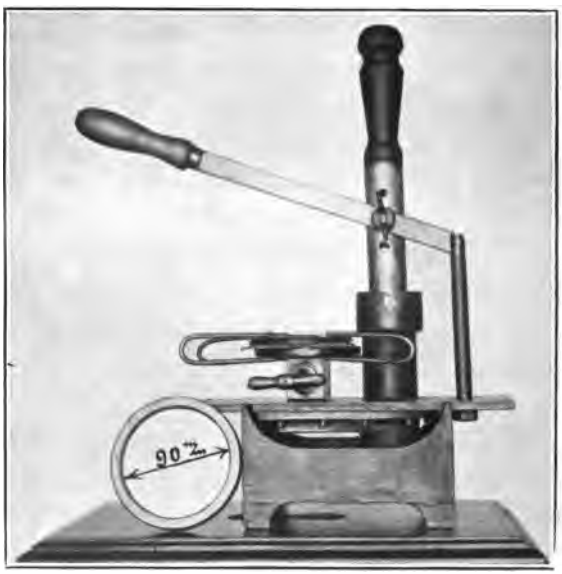


Fig. 3.

thus affording to the hand a better support during the manipulations; instead of the upper link the lever is provided near the screw of the piston with an oblong hole, which gives to the piston a slightly turning move-

ment. The under frame was intended for the use of charcoal firing and could, therefore, be dispensed with, in which case, the plate of the piston will be furnished directly with feet.

Below the outlet there is a cock which allows of the melted wax being kept back for a short while, or for the stoppage of the flow when the experiment is completed.

Great patience and practice are necessary for the successful manufacture of perfect objects which do not need to be better finished by hand. Nevertheless the cooled bed of the crater must be pierced through by a thick warmed needle, when it is desired to make a trickling cone.

For the making of a cake of wax a mould is to be used, the inner walls of which should be oiled before putting in the wax, and the latter should not be too warm, so as to prevent its adhering to the sides of the mould.

For those experimenters who might be disheartened or discouraged by failure, the following counsels may not be amiss.

(1) A number of cakes of wax must be prepared first, and when sufficiently cool, a hole is made in this wax of the dimensions of

the extreme peripheri which is to be given to the crater, as the cake of wax has a distinct tendency to become too soft during an extended (or very lengthy) operation.

(2) The piston must be warmed beforehand by placing the apparatus on its side on the hearth; afterwards the wax may be put in from above.

(3) The cake of wax should not be placed on the plate before ascertaining that the wax in the piston is warm enough.

During this time the piston, with lever, must be drawn up so high that it becomes clamped.

At the outlet from the cock are two pieces of pasteboard, and under the cake a piece of newspaper, all of which should have a perforation of at least 8 mm.

For holding the cake of wax a thin disc of tinplate or sheet metal is necessary, and for clamping the whole together four wire hoops are required.

In order to properly observe the forcing upward of the material, the apparatus should be withdrawn from the fire at the moment of putting on the cake of wax.

Now press up over the edge of the cake of wax the fluid wax, but without letting it

flow off, and then cause it to retire to the bottom of the piston so that there may follow one expulsion of between three and eight seconds duration.

When the edge is found to be sufficiently developed the melted wax may be allowed to flow back to the desired depth, then shut off the cock, and fan some air to the cake, by means of a piece of cardboard, in order to accelerate the cooling.

When, after some minutes, the bottom of the crater has taken the yellow colour of the wax, remove the pasteboards horizontally, and, a little later, pass the blade of a knife between these pasteboards and the sheet of newspaper, and the work is for the present completed. At the resumption of the experiment time must be given for the cock and the channel to have become sufficiently warmed by the heat, the latter being opened by the passing of a warmed knitting needle through the cock and canal. The raising of an oozing cone demands, with regard to the minimum quantity of fluid mass which is required, another apparatus which is shown in fig. 4.

The foot of this apparatus is the same as (or a new inferior part of) the apparatus

shown in fig. 3. The piston has only a width of 7 to 8 mm. The button of wood serves as a support for the goldfinger. At the outlet a horizontal plate has to be fastened as in fig. 3.

Every bottom of a crater on the moon had its fluid nucleus so long as the cooling

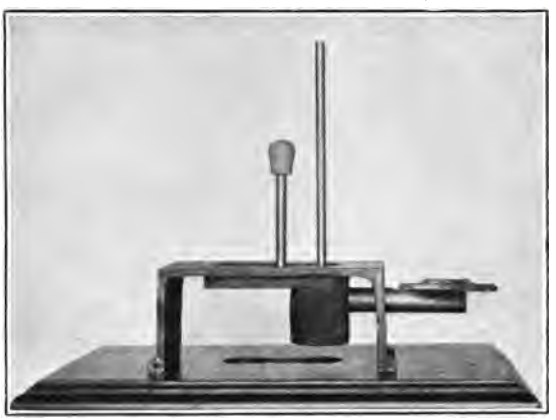


Fig. 4.

process allowed of an expulsion. In our case the use of a warmed knitting needle suffices for the making of a passage for the wax, the surface of the ebullition, however, must not be touched.

These manipulations are the best means of imparting the mechanic principle of the

typical elevations of the moon to persons who have had no opportunity of observing the action of fire-melted masses.

The author feels quite assured of the

Fig. 5.

success of the above described melting process in miniature, and strongly recommends the trial of these experiments. The author would be very pleased to see photographs of such successful experiments made by

other persons, as the study of such a display is not without scientific value.

In figs. 5 and 6 will be seen representations of wax ebullitions which were made without much practice, and yet the apparatus fig. 3 had then no cock for stopping the flow of melted wax. The crater of Brüg in the Parisian Atlas, and other craters,

Fig. 6.

show, however, a great similitude to the middle-sized crater shown in fig. 6.

The following remarks have reference to the illustrations of objects made by the author with apparatus shown in figs. 3 and 4.

Fig. 7 represents the plain of a rampart

of the Archimedes order, for the formation of this model the shutting of the cock of apparatus was necessary.

Fig. 8 represents a so-called *Cassini* which

Fig. 7.

was formed by the apparatus, fig. 3, while the apparatus, fig. 4, is better adapted for the production of small craters and trickling (or oozing) cones.

Fig. 9 shows a delicate ebullition of the

plain of a rampart, though it would be still too high with regard to the greatest dimensions. There had been made attempts at

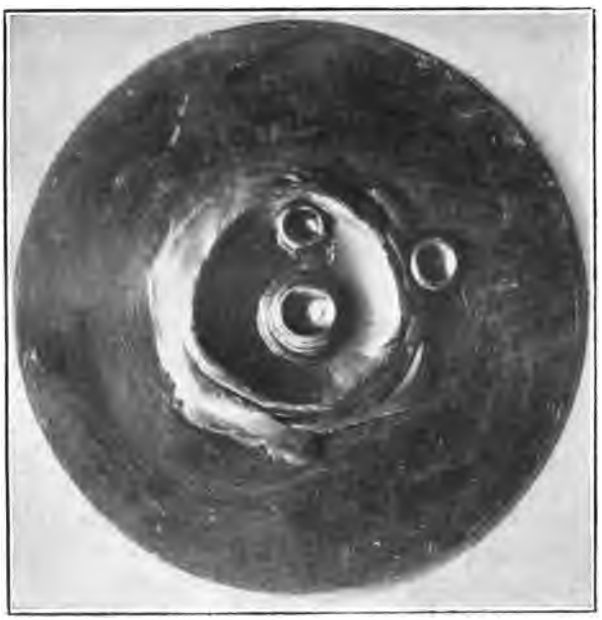


Fig. 8.

calculations for ascertaining the dimensions and the extent of space of the ramparts, but without success, as there existed different factors which influenced, unfavourably, those computations. The factors are the

following: The state of cooling of the ground at the beginning of the eruptive action, the temperature and the quantity of the gases, the temperature of the magma and its quantity, the periodicity of the ebullitions, and their duration, which was never unalterable (always liable to change).

Fig 9.

Out of these factors result innumerable variants, which explain that the principle of the round elevations on the moon must be the same from the smallest to the largest rampart.

Fig. 10 shows a fine annular rampart with a deepened ground. This figure serves to contradict the opinion that the ramparts had not a circular shape, as the annular form seems to be the regular shape, while other forms are the exception.

Fig. 11. A very well-known object on the moon is the Wargentin, which has become filled by a course of strong oozing without discharging gases. This object (Wargentin) cannot have been over-filled, as the over-flowing liquid would have worn a channel for emptying itself more completely. Of course the ebullition which we have in

Fig. 10.

this instance (fig. 11.) does not quite suit for comparison with Wargentin, which has only low ramparts.

Fig. 12 represents a strong ebullition from an ordinary crater.

Fig. 13 is a type of a real Tycho-bowl or cavity.

Fig. 14 shows a plain of a rampart, as

of bladder craters, which can easily be made with the apparatus fig. 4.

Fig. 15 represents a combined plain of rampart with different ebullitions, of which the Clarius represents the most superb example.

Fig. 16 represents the twin-like Theophi-

Fig. 11.

lus and Cyrillus, although the ground of Theophilus lies at a much greater depth than it is in reality.

The marks of the termination of the action of eruption on the moon are very different in character. In many crater basins the magma which flowed back has apparently hardened horizontally, and become flat in the process of hardening, while others

have formed more or less large oozing cones by the effort of ebullition, inflations, or by oozing.

All men have wondered that not one of these oozing cones have reached the height of the surrounding rampart, and yet the answer to the question is almost given,

Fig. 12.

when we consider that the cooling process at a minimum rate of advance must soon have put an end to the last dying activity.

As there exists between pits and "bladder craters" only a difference with regard to size, so there exists up to the largest rampart, or ring plain, the concordance that they all work spasmodically, forming shores, which, as a phenomenon, is quite

contrary to the so-called Pales, Sinus, Lacus, and Mare-ebenen which extend themselves only by destroying the shores. The plain ramparts are mostly level inside in consequence of their extension, and they agree with the marsh-plains in that they are mostly covered by a crust of lava or

Fig. 13.

slag, and that their plains may be unsymmetrically garnished with pits and bladder-craters.

They might owe their origin to the increasing diminution, respectively, plugging or closing by the melting of other openings on the moon's surface, and to the formation of magma. It may here be said that with the sintering down of the last opening of the

crater in the period of surface hardening every ebullition must have ceased, and that elevations cannot since have been originated on the moon.

All those elevations of which we have spoken hitherto, were preceded by untypical, thin, fluid ebullitions which will presently be explained, and which may be call-

Fig. 14.

ed Alps, Apennines, Carpathians, &c., so as to be better understood. The reader will never find that at the foot of anyone of these ranges the crater had been wholly, or even partially, obstructed, while, on the contrary, the destroying of craters occurs simultaneously on the large plains. This fact proves conclusively, that at the time of the irre-

gular coagulating of the Alps, the other mass of the moon was not sufficiently compact for taking regular forms, nevertheless, the mass was still dense enough to carry the accumulation of magma for the forming of the Alps which seemed to be full of "bladders" which resemble swelled sealing wax.

Fig. 15.

All things point to the conclusion that after the above mentioned Alps, the remaining plain or surface of the moon was quite covered with craters, but before the formation of Palus, Sinus, Lacus, and the marsh plains. The above mentioned masses which are covered with lava or slag, and which were formerly glowing molten masses, show, very

distinctly, their work of destruction. The destruction from crater to crater as well as those through the glowing molten seas over cooled obstructions, form the most interesting part of the mechanic of the moon, as we shall have an opportunity to see by an excursion in the moon with the aid of the Parisian Atlas. So typical are all the phenomena, from the smallest

Fig 16.

pit to the largest rampart, so multifarious are the scenes of destruction in the relatively soon following period.

With regard to the craters, it may be remembered of the Tycho how he is standing as the sole new formation in the large chaos of round craters. As regards the formation of the marsh plains, it might be intimated

by the semi-melted craters of Fracastor, Gärtner, Doppelmeyer, Lee, and others, but all these are excelled by the under melting of the Apennines which represents the grandest work of destruction in the moon, and which may be likened to the clashing together of the two seas, Imbrium and Serenitatis, but more of this hereafter. The process of cooling must have had the consequence that most of the sources of magma were dried up, and that communications with the interior were always becoming fewer, but that those remaining were larger. These larger and concentrated explosions of magma, with their lava covers, formed for all the marshes, the beginning of a grand deluge-like period of destruction which resembles the eruptions following the earth's-granite period. The glowing molten marshes extended themselves in such a manner that they formed, with few exceptions, a chain of connected seas. On the lava covering of these seas we find the most perfect example of "bladder craters", which do not reveal any trace of brighter magma in their neighbourhood, as do Timocharis, Lambert, Picard, and others. The different crevices might also be mentioned, which form

minute elevations in the covering or surface of lava. The Parisian Atlas teaches that these crevices can only have originated from the heating of the ground, arrested by the formation of "mare", as those crevices often began at a certain distance from the shore, and on the other side of the remaining level plains, the "mare" do not permit of any other explanation than that of wrinkling, caused by horizontal pushing.

IV. The Rays.

While the larger craters of Copernicus, Aristoteles, Eudoxus, Atuolycus &c., can prove the most violent explosions, the magma at their bases extend for considerable distances from other craters, as Tycho, Kepler, and Copernicus, which, in consequence of their rays, have occasioned scientists to form the extraordinary opinions referred to more fully in the following pages. There came a time when the openings which were not yet closed by the melting, were so few in number that the explosions were confined to a very few open craters, and, consequently, the pressure in the interior was proportionately augmented. Then began

the combat of the suffocating, which fact can be recognised by the length of the rays, by which we know which of them were the latest on the moon; whereupon any activity with regard to new magma explosions was confined to the interior. The Tycho distinguishes itself not only by the length of its rays, but there are other characteristics which help to explain its latest explosion and activity. With regard to the expulsion, it may be observed that the inertiae made itself remarkable by the greater length of the beams which are reflected into the moon's orbit. Furthermore, the crater itself, speaking for its latest activity, in its irreproachable state, forms the sole remaining intact crater in its extensive vicinity. At these latest occurrences there had been more beams of magma spurted out than by all the other craters combined.

V. The Lacerations of the Moon.

The brittleness of the mass of the moon has been recognised by many astronomers, and that evidently by the presence of its lacerations or clefts. Our previous recital, indeed, does not allow of any other inter-

pretation. It lies in the nature of the matter that progressively towards the surface everything must be dissected into details by the violent cooling process of which the two broken pieces of glass shown in fig. 17 give some faint idea. In the same way as a partial warming can cause wrinkles, there occurs the contrary, namely a straining rent when a partially warmed plain is cooled. It can be postulated that the violent cooling of the evidently brittle mass has filled it with rents, or crevices, in such a way that there do not exist, at least near the surface, pieces measuring one yard in length which do not show any crevice. It is, however, not the crevices supposed to be visible from the earth which afford us this enlightenment, but the accompanying phenomena caused by the real rents revealed in the above mentioned state, of which fact the reader may take special notice.

Loose masses, or boulders, probably do not exist on the moon, in general; nevertheless, the spurting and subsequent cooling of the mass may have caused the formation of some boulders. Much more important, however, are the precipices, caused by the immense formation of narrow clefts, or chinks,

and which have left such broad scarps, that the latter can be seen from the earth, while we could, with difficulty, discern the chinks, even with the aid of powerful instruments of observation. It must occur to every astronomer that the clefts are too wide in proportion to their length. The light effects of these chinks also teach the observer that

Fig. 17.

we have not to deal with sharp vertical incisions, but more with slopes of filled-up ditches, the crushed, or crashing masses of which must be more brilliant under advantageous illumination, than the dark cover of slag, scoria, or lava. While the brittleness of the moon's surface can already be recognized by the crevices, and while it leads

to the opinion that the whole surface must be torn by the violence of the cooling process, we have, on the other side, the most resplendent ratification of this opinion in the sole provable cold glidings into the chinks or slits.

VI. Changes on the Moon.

The observations hitherto made force upon us, in the first line of postulation, that after the suppression of the activity of the Tycho, there was no more the possibility of further eruptions on the moon, consequent upon the advanced state of the cooling process; otherwise the moon would have burst asunder.

This process of cooling was quite different on the earth, in consequence of the greater amount of heated masses. The effusions which formed the "mare" plains on the moon continued on the earth so long, through subsequent periods, until the crust of the earth became thicker by about an additional 40,000 meters, for the results at the construction of the tunnels of the St. Gotthard

and the Simplon lead us to presume that glowing molten lava would be met with at a depth of about 42,000 meters. (According to Archenius at 40 kilometers, and to Humbolt and Elie de Beaumont at 40 to 50 kilometers.)

The exertion of the investigators of the moon is especially turned upon the desire to discover new formations, to assert the disappearance of structures hitherto existent, or to perceive mechanic changes. Changes in the sense of an originating process, as in the case of the spring season on the earth, do not occur on the moon, since its relatively short period of cooling, which is still more remote than the first period of the earth's formation. The frequently mentioned principles, a real crater, caused by hot gases or magma, cannot be spoken of; although spectacles caused by meteorous contacts can be observed and may be regarded to be real craters.

With regard to the changes, it may here be remarked that on the moon, according to observations hitherto made, there may be possible the following causes or conditions:— (1) Meteorous contacts; (2) Crashing

together of bladders, so-called, and of crusts; (3) the formation of rents or crevices.

When a large meteor comes into contact with the lava crust of a mare plain, then the smashing of a glassy or slaggy mass takes place, accompanied by a change of colour to white. This change may be compared to the white spot which is produced on a black lime-stone through a blow being struck upon it. Away from the mare plains, and, especially, in the Alps, such a contact could be found out only in the case of a "bladder" being crashed at the time of this contact, which fact might be registered as the new formation of a crater.

Let us pause a few moments in contemplation of these crevices or chinks. While there existed an epoch on the moon in which the largest clefts by partial overflowings, and heatings with following reinforcement, had a very local character, there are now new chinks, which are at this time still possible on the moon, and have a more general importance.

Therefore, we shall never find, for example, that there originates a new cleft in the Gassendi, on account of the Gassendi, or in

a marsh on account of the marsh itself, because it could be easily perceived if it were so, by their length and direction; the clefts of to-day however, owe their cause to a general disposition for cooling. Such a rent, which is dependent on the straining of the surface of the whole moon, has no connection with the other conditions of the surface, as the direction is given by more general dispositions; a cleft could therefore take place athwart the Alps as easily as lengthwise.

Mädler has expressed the same opinion with regard to the exclusion of any new formation at this epoch. We find the following passage in "Klein's Manual of General Astronomy 1901", p. 121, art. 11, in reference to the changes on the moon's surface: "So numerous may be the revolutions which the moon's surface seems to have suffered that they must all surely belong to a very remote period. Annular mountains, or similar big formations, do not now occur on the moon; the observations made by Mädler have even led him to the following opinion: On the moon everything has now arrived at a state of tranquillity." Klein denominates this opinion as false, and refers to discoveries which cannot be denied,

but as to the reality of which different opinions may be held.

Though the formation of clefts and the contacts scarcely belong to those changes which were referred to by Mädler under the term "movements", it must, in addition to the noting of still possible changes, be considered that his opinion is right. Less fortunate seems an expression of Wislicenus: — "So much still follows out of the hitherto existing opinions that one cause cannot be sufficient for the explanation of the origin of the formations on the moon, or, that we must presume, at least, the development of such different formations having occurred also in totally different epochs.

To this intimation the author must remark that it has been the acceptation of so many different mechanic factors and epochs which has formed the greatest impediment to the hitherto conceived astronomy of the moon. It was the same with the theories of the volcanic analogies of the earth. At the end of this chapter the answer which was given to the author by a qualified astronomer will be found.

With reference to an article in an astronomic journal, the author made to a cele-

brated astronomer known to him the remark: "If only a wart more or less on the moon would once be a matter as indifferent to the astronomers as it is to me!"

The answer of the learned man was as follows:

"Your opinion on the importance of the so-called discoveries of miniature formations on the moon is surely shared by most astronomers, with the exception of those who make, from time to time, a little noise about such trifles. Some years ago, these discoveries followed one after the other, but without receiving great attention. It would be different, however, if a certain part of the surface were systematically examined from time to time and if this particular part should show though very small new formations; but for the general explanation of the topographic formations much would not be gained, probably nothing. The wished-for time for the astronomers is already at hand!

"None of those who know the right way of investigating the moon, would wish for further material for observation. It is still striking that so few occupy themselves with the moon from a physical point of view, but,

of course, to-day everyone engaged in the study of astrophysics turns to the spectroscope to speak the first word, and with that aid only, much cannot be found on the moon". The author joins his opinion to the views of this illustrious learned man.

In no very distant time science might conquer this point of view, where it has not already done so, that pretended discoveries of miniature formations on the moon are not able to give good explanations for the mechanic principle of the structure of the moon's surface, and that, on the other hand, in the present state of astrophysic photography the latter ought to furnish the proof of new discoveries on the moon. The reader may find this intimation somewhat superfluous in this place, but he must take into consideration that much of the present literature is often very far from making any mutation in this department of the astronomy of the moon.

VII. The Diverse Theories of the Moon.

After what has been said hitherto, this chapter might give occasion to many commentaries, and everyone who dedicates him-

self to this criticism is convinced that of ten different theories of the moon, nine must be false. This is poor consolation, but it reminds us of the many absurdities which have been stated about the moon. He would indeed be a very instructive critic who could explain the reasons for banishing these unjust assertions to the realm of the fairy-tales. However, the author finds it better for his purpose, to suspend a commentary for the present, as he may, probably, have opportunity to make some comment hereon later. Without laying claim to infallibility, the author cannot forbear to touch, with the aid of literature in his possession, the nature of some of the theories of the moon.

A rather considerable number of investigators advocate the theory of violent contact according to which the craters, with or without cone, owe their origin to meteors falling upon the moon, and whilst making a depression, forced out the surrounding surface. An authoress makes a significant remark in this connection, as follows:

"Perhaps these celestial projectiles have bored into the slowly cooling surface the deep round dungeons. This is a conjecture which time may yet prove to be correct;

in the meanwhile, they do not cause damage so long as we do not declare them to be proved truth".

According to another theory the annular ramparts were caused by whirl-storms. This theory, however, is thrown into doubt by the question: how such strong whirl-winds could be possible on the moon which has scarcely any atmosphere!

Yet another theory teaches that volcanic action has thrown up the mountains on the whole surface, and that by shrinkage, or concussion, these mountains crashed together into the cavity or hollow, so causing crateriform apertures. Another not very simple theory denotes glowing molten matter in flow and ebb, as being the cause of the annular ramparts. The representation, however, is so fantastic that a further description must be omitted. More fitting for a moon theory is the comparison made with the boiling over of the lava lakes in the Hawaii Islands.

For the formation of the craters a theory exists according to which loose masses of lava had been thrown out from a centre, and that this lava fell at some distance from the centre, thus forming, in the lapse of time, a crateriform rampart.

For the elevation of "Platos" we know of another theory according to which the internal expansion had pressed out of the crust round discs of the size of "Plato", and that the magma had come out of that circular hole and so formed the rampart.

A further theory states that the disappearance of the moon's atmosphere had the consequence of causing a stronger cooling of the equatorial continents than that of the polar continents which were already cool. In these conditions the equatorial regions had the tendency to become slightly crooked, with the consequence that the masses began to float down towards the equatorial seas, while for the craters the theory of volcanoes formed the basis.

Several selenographers also claim the theory which more nearly approaches that of the author. The reasons why they could not study the matter more conclusively are already explained in the first chapter.

The variety of a whole series of theories which are still spread throughout the most recent works and publications has been so great that the most learned astronomers accept very sceptically the treatments and results hitherto made. The author confidently

hopes that this may be changed, and that the capacities of astronomy and astrophysics will not leave unattempted the exploiting of a theory which is based on rich practical experiences.

VIII. An Excursion on the Moon.

The preceding chapter may not have been sufficient for the proper understanding of what the author's intention was to convey to his honoured readers. An explanation, accompanied by illustrations of the objects, is preferable to the most lengthy descriptions, especially when these objects can be demonstrated by nature or by good photographs.

For the purposes of these demonstrations the Parisian Atlas of the Moon (Lœwy and Puiseux) is very well adapted, and this is probably in the possession of most readers interested in this subject. It is clear that on this subject alone a large work might be written. It is, however, the author's intention to treat here on such points only as are specially instructive with regard to the mechanic of the moon. In this agreeable way he hopes to arouse many astronomers

and astrophysicists from their not altogether illegitimate passiveness and to re-animate them for a fruitful study. The author confidently hopes that the obstacle which had hitherto been considered as insuperable by scientists will, by this little work, be removed, and that the way may thus be made smoother for the satisfactory study of the surface of the moon.

It may be once more observed that in speaking of the movements of masses (except crashes) the glowing melted state has always been assumed.

The fascicles of the selenographic Atlas of Lœwy and Puiseux may now successively be treated.

Fascicle B.

VI. A terrible chaos presents itself to the observer. The mutual destruction has, with the exception of Tycho, not left a single large crater entire, as for example, the south end of the Faraday. The crater ramparts often exhibit bubble-craters on the summit of the crown. A rent, caused by the cooling process had conducted the hot gases to this place; then the cleft became a whole, and the formation of a bubble-crater began.

This plate is very instructive, inasmuch as it shows that the formation of oozing cones seldom occurs in violent stormy periods, and that, therefore, such cones rarely exist on large craters, while the bubble-craters preferably rise during a period of disturbance.

VII. The mythical Tycho, evidently the latest large crater formed, is the only remaining example of an intact crater. It is this crater which may thus be regarded as having been the last organ for the throwing out of magma, before the moon became what may be called "suffocated". In the south we find the most superb and complicated crater, Clavius, which is surrounded by much magma and many bubble-craters. There cannot be found on this plate any other oozing cones besides that on the Tycho, which had been quietly formed after the "final eruption." The destruction of the Lexell shows that at its northern foot a glowing melted marsh had existed.

VIII. The observer is struck by the wrinkles in the "Mare Humorum" and by the clefts through the Hippalus, the genetic connection of which cannot be doubted.

The wrinkles originated by expansion below the warm masses. After the destruc-

tion of a part of the mountains and of the Hippalus the glowing melted flushes found their way to the south-west, where the flowing off was followed by a rapid cooling process which caused three clefts of tension radial to the centre of heat.

At the uttermost rent two craters were formed, of which the smaller discharged magma. The bubble-craters on the plains correctly show on the outside of the slope the lava crust, and inside the clear magma pit. A great number of large craters in the mare Nubium were destroyed by flushes.

IX. Copernicus has, of all craters, according to his aspect, thrown out the largest quantity of magma, so much that the uniting of all the surrounding seas is a consequence of these outpourings. The last efforts in the interior of Copernicus and Aristotle are distinctly visible on the bottoms of the craters. Lalande shows ejections of magma over the covering of lava. For the student of details it might be recommended to note all the undefinable white spots in the marsh plains (Mare-Ebenen) as the Lasell or Linné, which may probably be meteoric contacts, and which ought especially to be noted, while, on the other hand,

the search for the smallest craters or pores which this or that topographist had forgotten, or which might have been even newly formed, has no real value. *Science may be satisfied as soon as we understand what we can distinctly perceive.*

X. One of the most interesting parts of the moon is the Bay of the Apennines because the glowing sea has melted under the massive of the Apennines to the place of draught, and the masses in the plains are nothing else than rocks which have fallen into the sea, and of which the places of fracture are provable, as Messrs. Loewy & Puiseux have, we remark with pleasure, also rightly perceived. The temperatures were not sufficiently high to melt the fallen masses entirely. The junction of the Apennines with the Caucasus was molten throughout and the seas Imbrium and Serenitatis were connected. While Archimedes shows a dark lava bottom *Autolicus* and *Aristullus* have all overflowed the craters and their environs with magma. Also around the Manilius there is distinctly visible the overflowing by magma. Linné would appear to be more like a depression caused by contact than a crater.

XI. The wrinkles of expansion also show themselves here. The Sinus Iridium was formerly an inclosed sea. The wrinkles follow pretty closely what would be the old shore of that sea. Plato shows its dark lava crust. In the mare Frigoris are white spots, while in the mare Imbrium the bubble-craters show brightly through the dark lava cover.

Fascicle C.

XIII. Above are the mountains of the Caucasus which belonged to the Apennines before the uniting of the two seas. On the right is the Cassini, of which a model made by the author is shown in fig. 3, page 23. Below we find the large cross valley which exhibits a scratching as by a meteor at that epoch when the lunar crust was still in a plastic-tenacious state. By the enormous ejections of the Aristotle and Eudoxus to the north the greater part of the large craters were so destroyed and their ruins emerge as from marshes. Small craters there to be found in perfect state disclose quite distinctly their later origin.

XIV. At the top is the Tycho in the form

of a trough; but without horizontal bottom, a proof that it raged thoroughly.

At the north of the Lexell was a marsh which destroyed a part of it. In the neighbourhood of the above mentioned marsh, the two craters Hell were formed. A cleft signifies advanced cooling, wherefore the gases always, and the magma only occasionally, could subdue the cooled masses and make their exit at the surface. The so-called "railway" between Thebit and Birt is hardly a wrinkle, but an oozed cleft, which already existed before the formation of the marsh, and which is lava covered like the wrinkles, otherwise the light side would appear brilliant. Powerful flushes seem to have been furnished by the Bouillaud, in the environs of which the vestiges of many craters can be recognized under the cover of lava.

XV. This figure shows the Copernicus, which destroyed the Carpathians, joined the seas and at last overflowed the dark lava crust with fresh magma. Lalande has also thrown out magma.

XVI. This page forms a side-piece to the former, with the small, but more violent Kepler. Most of the newer formations are

of no importance. As a very nice bubble-crater Lambert shows itself under the lava cover, while several smaller craters, as for example Euclides eject magma.

XVII. When we contemplate the scene of this dreadful struggle, with its manifold forces we must not forget that before the formation of seas similar formations had already existed, for which the attentive observer finds a hundred proofs.

Fascicle D.

XVIII. Like no other picture, Clavius shows its wonderful form and magnitude which renders all attempt at description fruitless, if not impossible.

XIX. As before mentioned Bouillaud presents itself here as principal purveyor of the oozing masses to the south and its devastations are innumerable.

XXI. The Mare Crisium is one of the few which might not be directly connected with the united seas; but there exist only oozing canals between them. The south end of the mare Foecunditatis had been formed

by the ejections from Petavius and Langrenus.

XXII. In this figure a diagonal parallelism makes itself remarkable in the middle. To the question: in which direction did the streaming occur? we receive the indirect answer 'from Julius Caesar,' as the latter had been partially devastated in the direction from south-west to north-east. Later, there arose Manilius with ejection of magma on to the lava cover, then Bessel, Menelaus, Arago, Ritter, Ross, and others, which have all arisen later in more tranquil epochs. Linné appears as a white spot among several others.

XXIII. This table shows the best of the former connection of the Apennines with the Caucasus. The so-called cross-valley is also very visible. The ejections of magma from the Aristotle and Eudoxus are very prominent; the illumination of the environs of the Archimedes seems to prove its ejections of magma to the south. Pico and Piton distinguish themselves among the oozing cones, which are very seldom to be found in the more exposed parts of the surface. Plato makes itself always remarkable by its darker lava cover.

Fascicle E.

XXIV. The Raita valley shows here very distinctly that its cavity has not been formed by a stream, but more by the rolling movement or contact of a meteor at the time of the plastic state.

XXV. Several signs go to support the opinion that the Altai mountains formed the left shore of a streaming which led in the direction of Catherina, Theophilus, Toricelli, into the connected seas Nectaris and Tranquillitatis.

XXVII. The action of the above mentioned streaming is here again to be observed, as it has devastated the annular rampart around the Toricelli most completely. It is always interesting to observe the ramparts melted down by hot flushes, for example that of the Fracastor. The large wrinkle between Posidonius and Plana shows indubitably the parallelism with the shore, though wrinkles can also be found without this appearance.

XXVIII. This figure offers a scene of many devastations by the formation of marshes and seas. Of the ramparts destroyed by the flush, the Gärtner is the most strik-

ing, though the formations are more devastated from that point towards the North Pole.

XXIX. This representation must be reckoned by the globular parallelism; it will be observed that to the mare Crisium there were many ways open for the oozing canals, and that Volta represents the scant remains of a crater in a marsh.

Fascicle F.

XXX. This is a representation of great value for the student of the mechanic of the moon. An especially welcome object in the right western illumination would be the Wargentin, and we hope that in time we shall be able to get a better photograph of it. The Wargentin is the only object of the whole lunar surface which shows how an annular mountain or crater could entirely fill itself up to the brim by the quiet, though constant influx of magma free from expanding gases. In any case it had scarcely overflowed, and was apparently not completely molten through; by the richer supply of magma, however, it would have been

molten through and consequently would have been emptied. The sea Humorum shows how the flushes devastated the still present forms, whereby Doppelmayer, Hippalus, and Lee suffered the most, while Gassendi suffered less.

XXXI. On this figure a hitherto existing streaming shows itself especially well, which travelled from the Piccolomini along the Altai mountains, behind Catherina and Theophilus to the sea. The Fracastor which had been partly melted by the flush of the mare of Nectaris, distinguishes itself from the other ramparts. Though the mutual destruction of formations can be observed on the whole moon, the Theophilus and Cyrillus are still very favourable for study. The author here permits himself to remark his opposition to the opinion that the principal types of the annular mountains were polygonal. After the explanations hitherto given in this work it might be clear to everybody that the mechanical principle of the fluid-melted or gaseous ebullitions, where no obstacle exists, can only lead to the annular form and that any other geometrical form, excepting hazards, is impossible. The Cyrillus is a shallower crater than the later risen

Theophilus. This latter extended itself so energetically that it engraved a much deeper and equally wide crater into the mass, partially destroying the rampart of the Cyrillus. This phenomenon is to be found many hundreds of times on the moon, but never in such an exposed position. Of the Cyrillus it had formerly been affirmed to be more quadrangular than round.

XXXII. This plate also confirms the parallelism which has been caused by the streaming from the sea Tranquillitatis in the direction of the Julius Cæsar to the Apennines.

XXXIII. The three large "Platos" Ptolemaeus, Alphonse, and Albategnius also show that there exists no rule for the termination of eruptive activity by this category.

XXXIV. Belonging to the fine rarities on this illustration are the scanty ebullitions through the lava cover Piton, Pico, Mont Teneriffe and others. The supposed outflow of the Archimedes to the south is so to be understood that the lava-crust remained on the Plato, as for example an ice-covering of liquid. The whole represents a grand scene of the process of devastation.

XXXV. Here is the Aristotle in all its North Polar devastating compactness. The Terminator and the libration have been beautifully considered in this photograph. The reader may compare the Bürg with the ebullition produced in the author's experiment, fig. 6, page 29. The destroyed Gärtner as well as the Meton and Consorts, which form together a marsh, are splendidly to be seen.

Fascicle G.

XXXVII. This view signifies the agony of the moon. It is a phenomenon which occurs unfortunately too often in the iron foundry to the most difficult and precious castings; for when this furious spitting overcomes the light fluid state of the metal, the casting generally becomes a wreck, though it can, in spite of the destructive agitation, still be serviceable in so far as the metal in the mould comes to tranquillity during the light-fluid state. The reader may judge from this fore-knowledge of the iron founder as to the destiny of his work, that the occurrence and the causes of the spurt-

ing are well known to iron founders, and that the right explanation of this illustration may, without scruple, be given by them.

When this tempestuous act took place on the moon, the latter had surely no opening whatever on the side nearest the earth and scarcely any on the opposite side. By the exploding gases at the exit the magma was ejected sideways more than upwards, so that the trajectory of the magma spouts did not allow the latter to fall outwards from the ramparts, wherefore the department of the "dark rosette" could not be sprinkled over, in general. Like all the other openings this one of the Tycho had, at last, to fail in consequence of the deadness of the oozing process, so that the last expiring effort could only produce an oozing cone. Since this moment the gases only could come to the surface of the moon, and this only by the formation of clefts. Their beautiful craters may be found everywhere in great number.

XXXVIII. The preceding explanations belong also to this plate. Here the "rosette" is still more prominent. A small number of rays of magma, tangential to the crown of the rampart, have caused many

reflections, or scruples, which, however, the author does not share. The conviction that they could only have been thrown out of the trough of Tycho ought to be sufficient. By considering the cohesion and adhesion of the thrown-out masses at the walls of the tray, which latter can have much assisted the throwing about of these magma jets, or rays, it can easily be understood, why just the most visible rays gave occasion to this phenomenon, in which the increasing stiffening is demonstrated.

XXXIX. This plate evidently owes its presence to the engaging Petavius, which shows itself as a very eruptive formation, similar to Langrenus. Every spectator will find the cleft in the bottom of Petavius, very strange, while this cleft forms, on the contrary, a very welcome proof for the opinion which the author held long ago, before he studied the Parisian Atlas. It may be considered that only rich effusions could unite themselves with the cold ground on which they fell, which fact is accidentally disclosed by this striking cleft. The explanation is not difficult, as the shallowness and the double brim of Petavius have led to the supposition that a bottom with

brim has been formed which has no real connection with the mass of the crater, whereby in consequence of the heat in the striking mass of the oozing cone the disc with the border had to crack. This is quite a regular process when the masses are supposed to be brittle. Were the disc not jammed in the trough, the cleft would appear further from the brim.

XL. This table shows the mare Humorum in a very clear manner. Hippalus had been destroyed for the forcing of the south-eastern passage. In the south two lakes and the Doppelmayer became victims to this, and the embracing of the Gassendi had begun, the sea-shores of which had been much weakened. To the east of the sea there are clefts which were produced by causes coming more from the east, and to which also belong the marsh in which stands the Billy.

XLI. One of the unconnected seas shows itself here greatly enlarged. It is to be observed that the seas had almost become connected at the Proclus. It must also strike everyone looking at this illustration that the largest clefts are not to be found in the great sea plains, which fact has its

cause in the uniform distribution of the heat, and because the lava cover better isolates against the rapid cooling than the magma.

Fascicle H.

XLIV. It would be very desirable to have a continuation of this photograph to the north, so that a good Wargentin should find room enough on it. Eastward of the Schiller there was a devastating marsh.

XLV. This plate shows very beautifully the Fracastor and the Beaumont which had been destroyed by the mare Humorum; we also see, not less distinctly, the deeply excavated Theophilus and the direction of the stream from the Piccolomini along the Mont Altai to the sea Nectaris.

XLVI. This is a very suitable representation for the study of the furrow and crater of the Hyginus. This small furrow, or rill, is not totally without genetic connection with the longer furrow of Ariadaeus. With regard to the reality of the many observations made in the last century, the author will not allow himself to form a judgment; he only places himself at the point of view,